from the thalamus to the dorsal horn region of the spinal cord. In the animal studies, analgesia from periaqueductal stimulation appeared to be related to release of naturally occurring opiatelike substances, the so-called endorphins. The neurotransmitters involved in pain relief for lateral thalamic stimulation are unknown. To treat chronic pain in humans, these pain-inhibiting systems may be electrically activated by stereotactic placement of stimulation electrodes in either brain site. Pain may be relieved in 65% to 70% of patients by the brain-stimulating technique, with few complications and without interference with normal neurologic function. Excellent results have been obtained in patients with chronic back and leg pain after unsuccessful spinal operations. Good results have also been obtained in patients with chronic pain due to trauma, postherpetic neuralgia, anesthesia dolorosa and certain nerve entry injuries.

The technique of placing lesions in the dorsal root entry zone is based on studies that showed neuronal hyperactivity in the dorsal horn of the spinal cord following deafferentation. Made by either a radio-frequency electrode technique or with a laser, these lesions have relieved chronic pain in a high percentage of patients following spinal cord injury and avulsion of the brachial or lumbar nerve plexuses. Because this technique is used for treating pain following deafferentation, pain relief may be accomplished without further loss of neurologic function.

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Intraoperative Monitoring With Ultrasonography

VARIOUS METHODS have been used in the past to locate intraoperatively lesions of the central nervous system. These techniques have usually required that the neurosurgeon transfer static information from diagnostic imaging studies to the operative situation. By applying ultrasonography to neurosurgical procedures, it has become possible to utilize data as it is generated (real-time) in localizing lesions.

The usual method of scanning for intracranial lesions is to first scan transdurally with a low-frequency transducer. In this way, the operator may become oriented by identifying structures such as the ventricles and the falx cerebri. Once the dura is opened, the lesion may be further characterized by using transducers that provide higher resolution. When scanning the intraspinal contents, the surgical wound is filled with sterile saline that serves as a coupling agent. Using a high-frequency transducer, scanning is carried out in a systematic manner noting the position of structures such as the central canal. Using the scanner's computer, the depth and the size of intracranial and intraspinal lesions may be determined.

Intraoperative ultrasonography enables a surgeon to readily identify lesions with high echogenicity, such as solid tumors, hematomas, displaced bone and missile fragments, and those with low echogenicity, such as abscesses, syringomyelic cysts and enlarged ventricles. Excision, aspiration, biopsy or cannulation may then be done and monitored under ultrasonic control.

Except in infants with an open anterior fontanelle, an opening in the intact calvarium or the spine must be created to accommodate the ultrasonic probe. As intraoperative ultrasonography continues to be widely used in neurosurgical procedures, it is anticipated technology will provide probes requiring smaller bone openings.

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Diagnosis and Surgical Management of Cervical Syringomyelia

CERVICAL SYRINGOMYELIA is a cystic dilation that develops in the cervical spinal cord, typically originating in the region of the vestigial central canal. Clinically, syringomyelia produces pain and progressive sensory loss to pain and temperature modalities in the upper extremities and upper cervical-thoracic region and with time can lead to a complete loss of spinal cord function below the lesion. The natural history of syringomyelia is highly variable. While some patients' conditions improve or stabilize without surgical therapy, others deteriorate even with the most aggressive intervention. While the cause of cervical syringomyelia is unclear, it commonly develops in patients with the cerebellomedullary malformation syndrome (Arnold-Chiari syndrome) with obstruction of the outlet foramina of the fourth ventricle. In some cases, no causative factors can be identified. Posttraumatic syringomyelia can develop in patients with spinal cord injury, typically in those with complete traumatic spinal cord transection in the thoracic region. In these cases, indolent progressive loss of sensory and motor function above the level of spinal cord transection may indicate the development of a syrinx. Occasionally intramedullary spinal cord tumors can also be associated with cystic accumulations of fluid within the spinal cord that can mimic the syndrome of syringomyelia.

The neuroradiologic diagnosis of syringomyelia has been greatly facilitated by the development of magnetic resonance (MR) imaging, in that MR imaging provides a complete visualization in the sagittal plane of the cervical cord, craniocervical junction and related regions. Also, associated hydrocephalus, cerebellar tonsillar and posterior fossa abnormalities can be visualized with their relationship to the cervical spinal cord. Operative strategies may be planned based on the MR imaging data. In addition, its use avoids invasive procedures such as myelography or cisternography and it can be done on an outpatient basis.

A large number of operations have been advocated for treating syringomyelia, including posterior fossa decompression with or without plugging of the communication of the

fourth ventricle with the central canal of the spinal cord, syringostomy with syringosubarachnoid shunting, terminal ventriculostomy, ventriculoperitoneal or ventriculoatrial shunting and syringoperitoneal shunting. The choice of procedure is based on the suspected cause of the syringomyelia and the anatomic data obtained by MR imaging.

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Surgical Therapy for Medically Intractable Epilepsy in Children

THE RENEWAL OF INTEREST in the surgical treatment of medically intractable epilepsy is well illustrated by the occurrence of two international conferences devoted to the subject in the past six months, after more than a dozen years without one. This renewed interest extends to the use of surgical approaches in children with difficult seizure problems. Cortical resection is the surgical approach most likely to completely control seizures. The indications for cortical resection in children in their early teens (and perhaps even younger) are the same as for adults: medical intractability, the presence of a focus of seizure onset and evidence that the focus is not in a brain area essential for motor, speech or memory function. Most of these patients will have temporal lobe epileptic foci. Medical intractability means a persistence of seizures after trials of the major antiepileptic drugs at therapeutic serum concentrations: phenytoin and carbamazepine alone and together for complex partial seizures of temporal lobe origin. Most patients who achieve seizure control on antiepileptic drug therapy do so within six months of reaching therapeutic drug concentrations. Children in their early teens with partial complex temporal lobe seizures seldom outgrow them; waiting for this to occur, therefore, is not a reason to defer surgical treatment. The more satisfactory rehabilitation that follows seizure control in the teens rather than the 20s is a reason to consider earlier surgical intervention.

Papers given at recent conferences indicated that no one diagnostic approach is suitable to identify a focus in all patients. In one subset of candidates who are particularly likely to have their seizures controlled by a surgical resection, the focus can be identified by noninvasive means without the use of depth electrodes or other techniques of ongoing direct brain recording. The exact noninvasive criteria used by various centers differ but often include localized interictal epileptiform abnormalities on scalp electroencephalography (EEG), evidence of fast motor responses and a lack of psychopathology on neuropsychological testing or measures of focal functional deficit, especially evidence of localized glucose hypometabolism on positron emission tomography. On the other hand, ongoing direct brain recording techniques have been of value in other patients who do not meet these noninvasive criteria due to bilateral, especially bitemporal, epileptiform abnormalities. In a large proportion of those patients, direct brain recording, coupled with intensive video and EEG monitoring, has shown that most or all major, socially disabling seizures arise from one temporal lobe. Surgical resection of that temporal lobe has a reasonable chance of controlling major seizures. A wide variety of ongoing direct brain recording techniques are currently in use, including stereotaxically implanted depth electrodes, subdural strips and tubes and subdural or epidural plates of electrodes. The advantages of each approach are still being determined.

The hemisphere containing the epileptic focus for language and memory is usually determined preoperatively by intracarotid perfusion of amobarbital (Wada test), a procedure that can be used in children as young as 6 years. If the focus is in the dominant hemisphere, the areas essential for language are localized by electrical stimulation mapping and these areas spared in the resection. The intraoperative use of this approach, however, requires the use of local anesthesia that children in the early teens, and perhaps younger, will tolerate. The use of epidural or subdural plates of electrodes provides an alternative technique to obtain the same localization information in children who cannot tolerate a procedure under local anesthesia. Resections can also be carried out in a temporal lobe essential for memory, but this requires sparing both hippocampus and lateral temporal memory areas as identified by electrical stimulation mapping. With the use of these techniques, the risk to language and memory is sufficiently low that having the epileptic focus in the dominant hemisphere is not a reason for deferring resection.

The decision to undertake a surgical resection should be made based on the impact to a child of the control of seizures alone. Behavioral problems do not reliably improve after an operation for seizure control, and this goal is not by itself an indication for surgical therapy for seizures.

Surgical therapy may also be of value in several special situations. In very young children, surgical therapy is usually reserved for intractable seizures with a clear focal onset; a substantial number of these children will have the distinctive pathologic changes of Rasmussen's encephalitis. Children with the infantile hemiplegia syndrome have a high probability of seizure control after hemispherectomy. Recent modifications in the technique of this operation seem to have reduced the long-term complication of bleeding into the resection site and the subsequent development of a communicating hydrocephalus. The value of sectioning the corpus callosum in the treatment of seizures is still being debated. There is a developing consensus, however, that it may have some value in patients with frequent major motor convulsive (grand mal) seizures without a focus and in frequent drop seizures where the patient is likely to sustain injury.

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